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## Standard Definitions of Terms Relating to Heat Treatment of Metals<sup>1</sup>

This standard is issued under the fixed designation E 44; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*These Definitions were prepared jointly by the American Society for Metals, Society of Automotive Engineers, American Foundrymen's Association, and American Society for Testing and Materials.*

*Temperatures have been omitted purposely from these definitions, which are not intended as specifications and should not be interpreted as such.*

<sup>ε1</sup> NOTE—The jurisdiction of this standard was changed in April 1989.

$A_{c_{cm}}$ ,  $A_{c_1}$ ,  $A_{c_3}$ ,  $A_{c_4}$ —See transformation temperature.

**age hardening**—hardening by aging, usually after rapid cooling or cold working. See aging.

**aging**—a change in the properties of certain metals and alloys that occurs at ambient or moderately elevated temperatures after hot working or a heat treatment (quench aging in ferrous alloys, natural or artificial aging in ferrous and nonferrous alloys) or after a cold-working operation (strain aging). The change in properties is often, but not always, due to a phase change (precipitation), but never involves a change in chemical composition of the metals or alloys. See also age hardening, artificial aging, natural aging, overaging, precipitation hardening, precipitation heat treatment, progressive aging, quench aging, and strain aging.

**annealing**—heating to and holding at a suitable temperature and then cooling at a suitable rate, for such purposes as reducing hardness, improving machinability, facilitating cold working, producing a desired microstructure, or obtaining desired mechanical, physical, or other properties. When applicable, the following more specific terms should be used:

- black annealing
- blue annealing
- box annealing
- bright annealing
- flame annealing
- full annealing
- graphitizing
- intermediate annealing
- isothermal annealing
- malleabilizing
- process annealing
- quench annealing
- recrystallization annealing
- spheroidizing

Definitions of the above terms are given below in their alphabetic positions.

When applied to ferrous alloys, the term "annealing,"

without qualification, implies full annealing.

When applied to nonferrous alloys, the term "annealing" implies a heat treatment designed to soften a cold-worked structure by recrystallization or subsequent grain growth or to soften an age-hardened alloy by causing a nearly complete precipitation of the second phase in relatively coarse form.

Any process of annealing will usually reduce stresses but if the treatment is applied for the sole purpose of such relief it should be designated stress relieving.

$A_{r_{cm}}$ ,  $A_{r_1}$ ,  $A_{r_3}$ ,  $A_{r_4}$ —See transformation temperature.

**artificial aging**—aging above room temperature. See aging and precipitation heat treatment. Compare with natural aging.

**austempering**—quenching a ferrous alloy from a temperature above the transformation range in a medium having a rate of heat abstraction high enough to prevent the formation of high-temperature transformation products, and then holding the alloy, until transformation is complete, at a temperature below that of pearlite formation and above that of martensite formation.

**austenitizing**—forming austenite by heating a ferrous alloy into the transformation range (partial austenitizing) or above the transformation range (complete austenitizing).

**baking**—heating to a low temperature in order to remove gases.

**black annealing**—box annealing or pot annealing ferrous alloy sheet, strip, or wire. See box annealing.

**blank carburizing**—simulating the carburizing operation without introducing carbon. This is usually accomplished by using an inert material in place of the carburizing agent, or by applying a suitable protective coating to the ferrous alloy.

**blank nitriding**—simulating the nitriding operation without introducing nitrogen. This is usually accomplished by using an inert material in place of the nitriding agent, or by applying a suitable protective coating to the ferrous alloy.

**blue annealing**—heating hot-rolled ferrous sheet in an open furnace to a temperature within the transformation range and then cooling in air, in order to soften the metal. The formation of a bluish oxide on the surface is incidental.

**bluing**—subjecting the scale-free surface of a ferrous alloy to the action of air, steam or other agents at a suitable temperature, thus forming a thin blue film of oxide and improving the appearance and resistance to corrosion.

<sup>1</sup> These definitions are under the jurisdiction of ASTM Committee A-1 on Steel, Stainless Steel, and Related Alloys and are the direct responsibility of Subcommittee A1.92 on Terminology.

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**NOTE**—This term is ordinarily applied to sheet, strip, or finished parts. It is used also to denote the heating of springs after fabrication, in order to improve their properties.

**box annealing**—annealing a metal or alloy in a sealed container under conditions that minimize oxidation. In box annealing a ferrous alloy, the charge is usually heated slowly to a temperature below the transformation range, but sometimes above or within it, and is then cooled slowly; this process is also called “close annealing” or “pot annealing.” See **black annealing**.

**bright annealing**—annealing in a protective medium to prevent discoloration of the bright surface.

**burning (burnt, burned)**—a term applied to metal which has been permanently damaged by having been heated to a temperature close to or within the melting range. This results in a structure exhibiting incipient melting or intergranular oxidation.

**carbonitriding**—a case hardening process in which a suitable ferrous material is heated above the lower transformation temperature in a gaseous atmosphere of such composition as to cause simultaneous absorption of carbon and nitrogen by the surface and, by diffusion, create a concentration gradient. The process is completed by cooling at a rate that produces the desired properties in the workpiece.

**carbon potential**—a measure of the ability of an environment containing active carbon to alter or maintain, under prescribed conditions, the carbon content of the steel.

**NOTE**—In any particular environment, the carbon level attained will depend on such factors as temperature, time, and steel composition.

**carbon restoration**—replacing the carbon lost in the surface layer from previous processing by carburizing this layer to substantially the original carbon level.

**carburizing**—a process in which an austenitized ferrous material is brought into contact with a carbonaceous atmosphere of sufficient carbon potential to cause absorption of carbon at the surface and by diffusion, create a concentration gradient.

**case**—*in a ferrous alloy*, the outer portion that has been made harder than the inner portion (see **core**) as a result of altered composition, or structure, or both, from treatments such as carburizing, nitriding, and induction hardening.

**case hardening**—a generic term covering several processes applicable to steel that change the chemical composition of the surface layer by absorption of carbon, nitrogen, or a mixture of the two and, by diffusion, create a concentration gradient. The processes commonly used are: **carburizing** and **quench hardening**; **cyaniding**; **nitriding**; and **carbonitriding**. The use of the applicable specific process name is preferred.

**cementation**—the introduction of one or more elements into the outer portion of a metal object by means of diffusion at high temperature.

**close annealing**—See **box annealing**.

**cold treatment**—exposing to subzero temperatures for the purpose of obtaining desired conditions or properties, such as dimensional or structural stability. When the treatment involves transformation of retained austenite, it is usually followed by a tempering treatment.

**conditioning heat treatment**—a preliminary heat treatment used to prepare a material for a desired reaction to a

subsequent heat treatment. For the term to be meaningful, the exact treatment must be specified.

**controlled cooling**—cooling from an elevated temperature in a predetermined manner to avoid hardening, cracking, or internal damage or to produce a desired microstructure or mechanical properties.

**core**—(1) *case hardening*—interior portion of unaltered composition, or microstructure, or both, of a case-hardened steel article.

(2) *clad products*—the central portion of a multilayer composite metallic material.

**critical cooling rate**—the minimum rate of continuous cooling to prevent undesirable transformations. For steel, unless otherwise specified, it is the slowest rate at which austenite can be cooled from above critical temperature to prevent its transformation above the  $M_s$  temperature.

**critical temperature range**—synonymous with **transformation range**. The term is of historic significance only, and its use is discouraged.

**cyaniding**—introducing carbon and nitrogen into a solid ferrous alloy by holding above  $A_{c1}$  in contact with molten cyanide of suitable composition. The cyanided alloy is usually quench hardened.

**cycle annealing**—an annealing process employing a predetermined and closely controlled time-temperature cycle to produce specific properties or microstructure.

**decarburization**—the loss of carbon from the surface of a ferrous alloy as a result of heating in a medium that reacts with the carbon.

**differential heating**—heating that intentionally produces a temperature gradient within an object such that, after cooling, a desired stress distribution or variation in properties is present within the object.

**diffusion coating**—any process whereby a basis metal or alloy is either: (1) coated with another metal or alloy and heated to a sufficient temperature in a suitable environment, or (2) exposed to a gaseous or liquid medium containing the other metal or alloy, thus causing diffusion of the coating or of the other metal or alloy into the basis metal with resultant change in the composition and properties of its surface.

**direct quenching**—quenching carburized parts directly from the carburizing operation.

**double aging**—employment of two different aging treatments to control the type of precipitate formed from a supersaturated alloy matrix in order to obtain the desired properties. The first aging treatment, sometimes referred to as intermediate or stabilizing, is usually carried out at a higher temperature than the second.

**double tempering**—a treatment in which quench-hardened steel is given two complete tempering cycles at substantially the same temperature for the purpose of assuring completion of the tempering reaction and promoting stability of the resulting microstructure.

**drawing**—a misnomer for **tempering**.

**ferritizing anneal**—the process of producing a predominantly ferritic matrix in a ferrous alloy through an appropriate heat treatment.

**flame annealing**—annealing in which the heat is applied directly by a flame.